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(54) Mercerisation of fibres

(57) Apparatus for mercerising fibres, eg of cotton, comprises a reaction kier (1) within which are two sets (3, 4) of steel meshes between which the fibres (5) are compressed to prevent contraction during mercerisation. The gases, notably oxygen and nitrogen, within the reaction kier (1) are drawn out by a vacuum pump and the reaction kier (1) is subsequently flooded with carbon dioxide gas. Mercerisation liquid is then applied to the fibres within the reaction kier (1), under pressure. The fibres are subsequently washed.

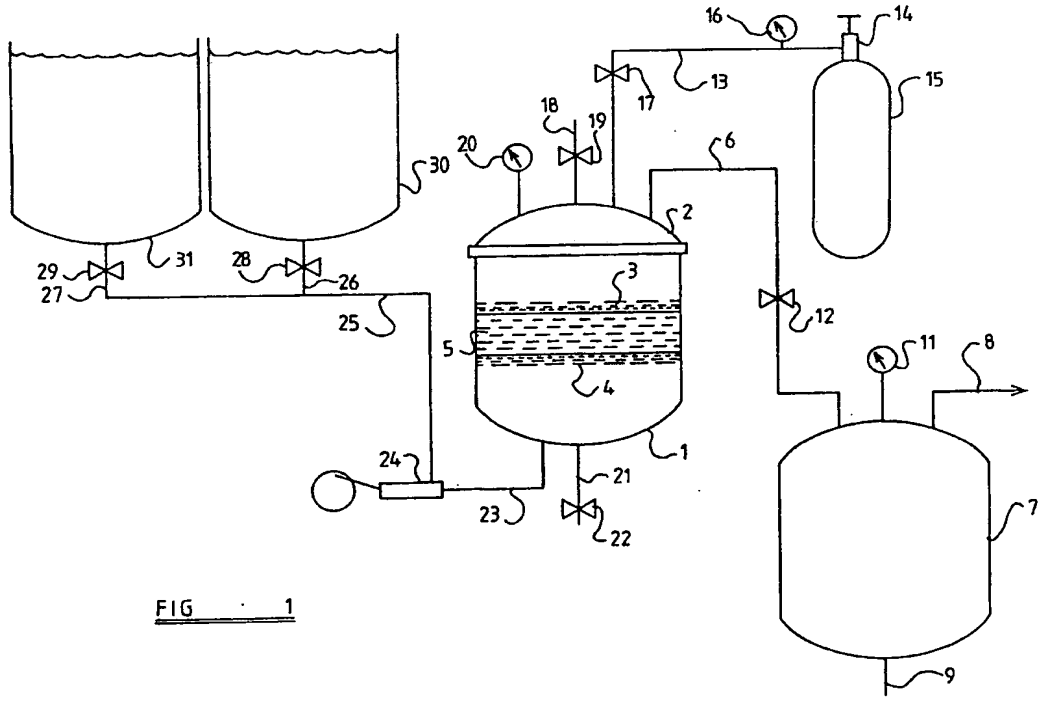

FIG 1

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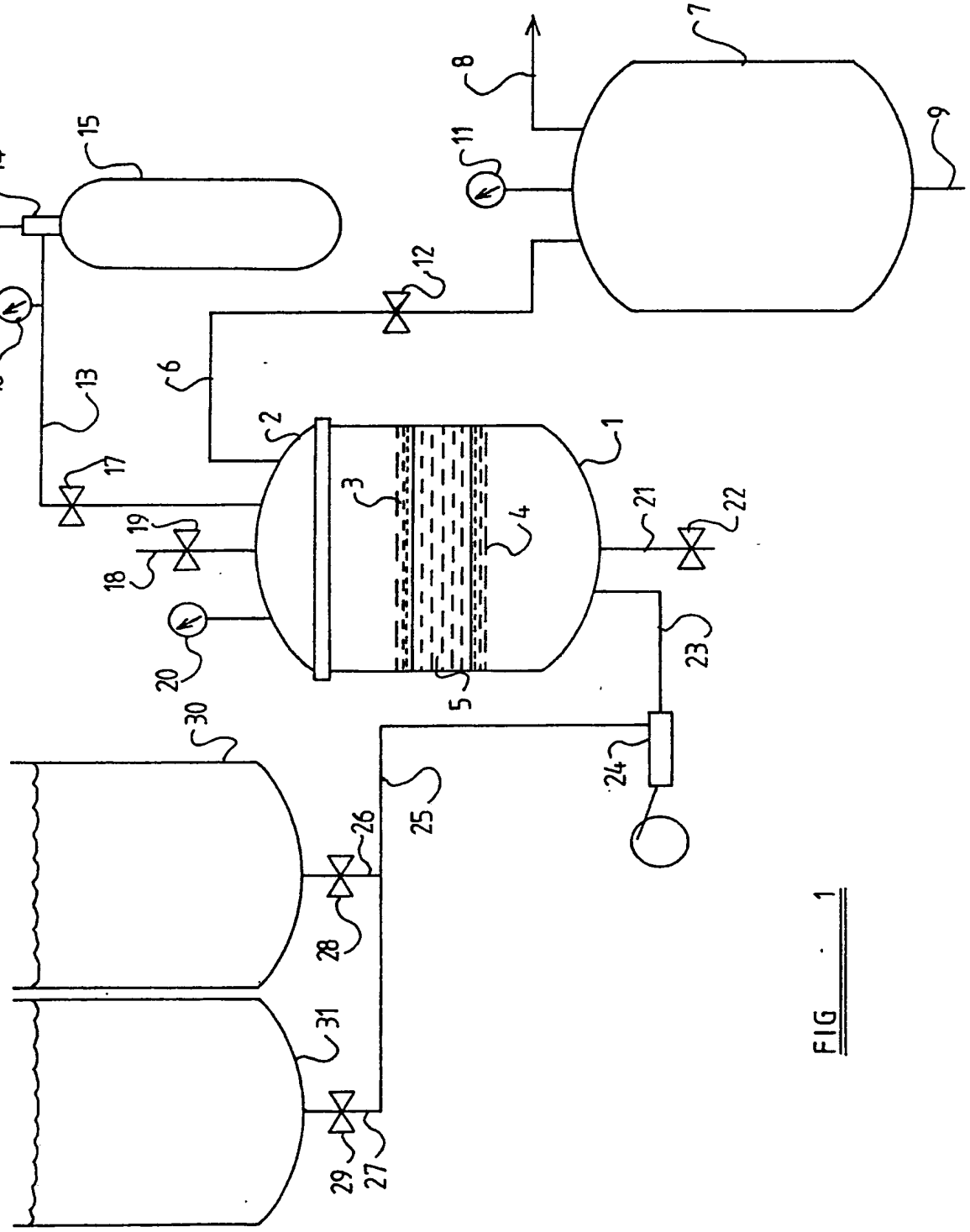
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FIG 1

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Description of the Invention:

Title: Apparatus and Method for Mercerisation of Fibres.

THE PRESENT INVENTION relates to apparatus for and a method of mercerisation of fibres and, more particularly, to apparatus for and a method of mercerisation of cotton fibres.

Mercerisation of fibres, particularly cotton fibres, is a pre-treatment method in the textile industry, carried out before dyeing and finishing of yarns. The process involves the caustic treatment of cotton fibre, commonly in the form of woven fabric, knitted fabric or ply yarn in the form of hank. The purpose of the treatment is to obtain greater lustre of the fibre, a higher exhaustion of dyestuff and a greater tensile strength.

In a prior art method, a solution of caustic soda having a concentration of between 250 and 350 grams per litre is applied to the cotton fibre, often with a wetting agent to shorten the processing time. It has been found that such application provides a good lustre in yarn.

Untreated cotton fibre has an oval shape similar to the cross-sectional shape of a kidney. When the fibre is treated with a mercerisation liquid, the fibre absorbs the alkali and swells causing the cross-section of the fibre to change to a circular form. At the same time, the chemical structure of the cotton cellulose is modified. This reaction and swelling of the fibre gives the advantages described above. To gain the advantages, the fibre is held under tension to prevent contraction during the process.

At present, the mercerisation of fibres occurs after the fibre has been formed into a fabric or a ply yarn. The yarn or fabric is then fed through mercerisation liquid under tension, for example by being drawn off a roller.

This process has the disadvantage that the yarn is ready formed and, therefore, the fibres cannot be mixed with other fibres to make fancy yarn.

Another disadvantage of the present process is that any faults and unevenness caused during the mercerisation process cannot be removed from the yarn because the yarn has already been formed.

A further disadvantage in the present mercerisation process is the problem of insufficient penetration of the mercerisation liquid into the fibre.

Accordingly, it is an object of the present invention to overcome, or at least mitigate, one or more of the above-mentioned disadvantages.

According to a first aspect of the present invention there is provided apparatus for mercerisation of fibre, which apparatus comprises a mercerisation vessel, means for tensioning the fibre to be mercerised, means for reducing the partial pressure of oxygen and nitrogen in the vessel and means for applying mercerisation liquid to the fibre.

It has been found that the presence of oxygen in the air surrounding the cotton fibres militates against the penetration of mercerisation liquid into the cotton fibres. Accordingly, the apparatus of the present invention provides means for reducing the partial pressure of the oxygen surrounding the fibres so that the mercerisation liquid may more fully penetrate the fibres and thus overcome or at least mitigate the problem of faults or defects caused by lack of penetration of the mercerisation liquid.

Preferably, the means for tensioning the fibre comprises clamping means, between which the fibre is compressed under pressure. The use of such apparatus for tensioning the fibre allows short slivers of cotton fibre to be held under tension and thus be mercerised. In this

way, raw cotton fibre may be mercerised prior to spinning so that any faults or unevenness in the mercerised fibre may be removed prior to spinning of the fibre into a yarn or fabric. Furthermore, the mercerised fibre may be spun into a yarn with unmercerised or other types of fibre to form a fancy yarn. Preferably the means for reducing the partial pressure of the oxygen and nitrogen in the vessel comprises a vacuum pump. Alternatively, the means for reducing the partial pressure of oxygen and nitrogen in the vessel comprises pump means for flooding the vessel with a relatively inert gas such as carbon dioxide. In the most advantageous embodiment of the present invention, the apparatus comprises both a vacuum pump and means for flooding a vessel with a relatively inert gas.

Preferably, the means for applying mercerisation liquid to the fibre comprises means for pumping mercerisation liquid into the vessel most preferably at a pressure greater than atmospheric pressure.

Preferably the apparatus further comprises means for applying washing liquid to the fibre.

According to a second aspect of the present invention there is provided a method for mercerisation of fibre, which method comprises the steps of tensioning the fibre to be mercerised to prevent contraction thereof, reducing the partial pressure of oxygen and nitrogen surrounding the fibre and applying mercerisation liquid to the fibre.

Preferably the fibre is tensioned by compression of the fibre to a density of from 500 to 700 grams per litre.

It is preferred that the partial pressure of oxygen and nitrogen is reduced such that the partial pressure of oxygen and nitrogen surrounding the fibre is from 5 to 8mm Hg.

Preferably the partial pressure of oxygen and nitrogen is reduced by reducing the atmospheric pressure surrounding the fibre. Alternatively, the partial pressure of oxygen and nitrogen may be reduced by flooding the space surrounding the fibre with a relatively inert gas, such as carbon dioxide. In a most preferred method of the present invention, the partial pressure of oxygen and nitrogen is reduced by first reducing the atmospheric pressure surrounding the fibre, for example with a vacuum pump, and subsequently flooding the space around the fibre with a relatively inert gas such as carbon dioxide. It is particularly preferred that this sequence of events is carried out more than once. In such a way, the majority of the oxygen in the gas originally surrounding the fibre is flushed away and replaced by an inert gas such as carbon dioxide.

Preferably the mercerisation liquid is applied to the fibre at a pressure greater than atmospheric pressure, more preferably at least 3 bars and most preferably at least 10 bars.

It is preferred that the mercerisation liquid is at a temperature at from 14° to 30° C. In particular embodiments of the present invention, the mercerisation liquid comprises either caustic soda preferably at a concentration of 28° to 30° Be (Degree Baumé) or liquid ammonia.

It is preferred that the method further comprises the step of applying washing liquid to the fibre in order to wash the fibre. The washing liquid may comprise water and is preferably at a temperature of from 60° to 80° C.

It is preferred that this method is used with raw cotton fibre or slivers.

For a better understanding of the present invention, and to show how the same may be put into effect, reference will now be made, by way of example, to the accompanying drawing in which:

FIGURE 1 is a schematic view of a mercerisation apparatus in the accordance with the first aspect of the present invention.

The apparatus comprises a reaction kier 1 of circular cross-section. The reaction kier 1 is an autoclave, made of high grade stainless steel, which can withstand static pressure of more than 10 bars.

The reaction kier 1 has a lid 2 which may be locked tight with an air seal and which allows access to the interior of the reaction kier 1. Within the reaction kier are positionable two sets of circular stainless steel wire screens 3, 4. The sets of screens 3,4 may be clamped together with the coarsest mesh screens on the exterior of the sets and the finest mesh on the inside. The two sets of screens, 3, 4 are designed to be clamped together with a bulk of cotton fibres or slivers 5 between them, such that the mechanical pressure applied to the two sets of screens 3, 4 is sufficient to prevent the bulk of cotton fibres or slivers 5 from shrinking during mercerisation.

A vacuum line 6 opens into the lid 2 of the reaction kier 1. The vacuum line 6 leads to a vacuum receiver 7. A vacuum pump line 8 connects the vacuum receiver 7 with a vacuum pump (not shown). A vacuum release line 9, having a vacuum release valve 10, opens into the vacuum receiver 7 for the purposes of releasing any vacuum with in the vacuum receiver 7, a vacuum pressure gauge 11 indicates the pressure within the vacuum receiver 7. The vacuum line valve 12 is positioned within the vacuum line 6 to open and close the vacuum line 6.

Also opening into the lid 2 of the reaction kier 1 is a carbon dioxide line 13 which connects the pressure regulator 14 of a cylinder 15, containing pressurised carbon dioxide, with the reaction kier 1. Attached to the carbon dioxide line 13 is a carbon dioxide pressure gauge 16 for indicating the pressure of carbon dioxide entering the reaction kier 1, and a carbon dioxide line valve 17 for opening and closing the carbon dioxide line 13. A kier pressure release line 18 opens from the lid 2 to the atmosphere and has, positioned in it, a kier pressure release valve 19 which allows the interior of the reaction kier 1 to be opened to the atmosphere. Also positioned on the lid 2 of the reaction kier 1 is a kier pressure gauge 20 for reading the pressure within the reaction kier 1.

A liquid drain line 21 opens from the bottom of the reaction kier 1 and has a liquid drain valve 22 therein to open the liquid drain line 21. Also opening into the bottom of the reaction kier 1 is a liquid input line 23. This liquid input line 23 connects the reaction kier 1 with a piston pump 24 which is capable of pumping liquid into the reaction kier 1, via the liquid input line 23, and pumping liquid out of the reaction kier 1, via the liquid input line 23. Leading to the piston pump 24 is a liquid feed line 25 which branches into a mercerisation liquid feed line 26 and a water feed line 27. The mercerisation liquid feed line 26 has a mercerisation liquid feed valve 28 therein to open the mercerisation liquid feed line 26 and the water feed line 27 has a water feed valve 29 positioned therein to open the water feed line 27. The mercerisation liquid feed line 26 opens into a mercerisation liquid reservoir 30 and the water feed line 27 opens into a water reservoir 31.

Mercerisation of cotton fibres, according to the second aspect of the present invention, takes place as follows. Firstly fully combed cotton slivers or fibres 5 are compressed between the two sets 3, 4 of wire screens and the wire screens are clamped together so as to compress the cotton 5 to a density of about 500 to 700 grams per litre. Such compression of the cotton fibres 5 prevents contraction of the fibres 5 during the mercerisation and washing processes. The carrier, formed by the two sets 3, 4 of wire screens, with the cotton fibres 5 clamped there-between, is then hoisted into the reaction kier and positioned therein. The lid 2 of the reaction kier 1 is then closed, forming an air-tight seal. The carbon dioxide line valve 17, the kier pressure release valve 19, the liquid drain valve 22, the mercerisation liquid feed valve 28 and the water feed valve 29 are all closed and the vacuum line valve 12 is opened. The vacuum pump is operated and, after approximately five minutes, the vacuum line valve 12 is closed and the carbon dioxide line valve 17 is opened, allowing the reaction kier 1 to fill with carbon dioxide gas from the carbon dioxide cylinder 15. After approximately a minute the pressure within the reaction kier 1 rises to 1 bar. The carbon dioxide line valve 17 is then closed and the vacuum line valve 12 is opened again. The vacuum pump is then operated and the gas within the reaction kier 1 is pumped out until the pressure within the reaction kier 1 again drops.

The mercerisation liquid feed valve 28 is then opened and mercerisation liquid, here caustic soda at a temperature of between 14° and 30° C is pumped into the reaction kier 1 by the piston pump 24. The caustic soda is pumped in until the pressure of caustic soda within the reaction kier 1 is 10 bars.

The purpose of flooding the reaction kier 1 with carbon dioxide prior to mercerisation is to expel the majority of the nitrogen and oxygen from the reaction kier. If a vacuum pump alone is used, it may take up to 48 hours to produce 5mm Hg of oxygen and nitrogen. However, if carbon dioxide is within the reaction kier 1, 5mm Hg of oxygen and nitrogen may be quickly obtained if another 20 to 60mm Hg pressure is produced by carbon dioxide gas. If, for example, the kier is flooded twice with carbon dioxide and the gas is each time extracted under vacuum, the atmosphere surrounding the cotton slivers of fibres 5 will contain 99.9% of carbon dioxide and only 0.5% of oxygen and nitrogen. When the caustic soda is pumped into the reaction kier 1 the carbon dioxide gas dissolves in the caustic soda in the following chemical reaction:

$$CO_2 + NaOH \quad Na_2CO_3 + H_2O.$$

Both the sodium carbonate (Na_2CO_3) and water dissolve in the caustic soda. This, along with the reduced pressure of oxygen and nitrogen, means that the caustic soda can penetrate throughout the entire bulk of cotton slivers or fibres 5, despite the cotton slivers or fibres 5 being under pressure. This is assisted by the caustic soda being at a pressure of 10 bars, although a pressure as low as three bars has proved to be sufficient.

Liquid ammonia may also be used as the mercerisation liquid. Previously, liquid ammonia has not been used as a mercerisation liquid because of the problems created by ammonia vapour given off from the liquid ammonia. In the present apparatus there is no problem with the recovery of liquid ammonia because the system used is a closed system. It has been found that the mercerisation effect of liquid ammonia is better than mercerisation carried out using caustic soda.

After the mercerisation of the fibres with the mercerisation liquid is complete, the mercerisation liquid feed valve 28 is opened and the mercerisation liquid is pumped, by the piston pump 24, out of the reaction kier 1 back to the mercerisation liquid reservoir 30. To prevent a vacuum being formed in the reaction kier 1 by this process, the kier pressure release valve 19 is opened allowing the pressure within the reaction kier 1 to equalise with the atmospheric pressure through the kier pressure release line 18. When the mercerisation liquid has been pumped from the reaction kier 1, the mercerisation liquid feed valve 28 is closed and the pump 24 is halted. The kier pressure release valve 19 is then closed, the vacuum line valve 12 is opened and the vacuum pump is operated. At the same time the water feed valve 29 is opened and the pump 24 is operated to pump water, at a temperature of between 60° and 80° C, into the reaction kier. This process is hastened by the vacuum formed within the reaction kier 1, by the action of the vacuum pump, drawing the water in from the water reservoir 31. When the reaction kier 1 has filled with water, the vacuum pump is turned off, the vacuum feed valve 12 is closed, the kier pressure release valve 19 is opened and the liquid drain valve 22 is opened and the water is drained from the reaction kier 1. This washing process is repeated three times to fully wash the mercerised slivers or fibres 5. The liquor to goods ratio is 30 to 1 by weight. The washing step is subsequently repeated with a suitable amount of anionic softening agent added to the hot water. After this final washing step the sliver or fibre bulk is removed from the reaction Kier and then centrifuged and dried using a high frequency drier. The mercerised slivers or fibres can then be spun to produce yarn or thread.

In this way raw cotton fibre may be mercerised, prior to spinning, quickly and efficiently and with suitable penetration of the mercerisation liquid to all areas of the fibre.

CLAIMS:

1. Apparatus for mercerisation of fibre, which apparatus comprises a mercerisation vessel, means for tensioning fibre to be mercerised, means for reducing the partial pressure of oxygen and nitrogen in the vessel and means for applying mercerisation liquid to the fibre.

2. Apparatus according to Claim 1, wherein the means for tensioning fibre comprises clamping means between which the fibre is compressed under pressure.

3. Apparatus according to Claim 1 or 2, wherein the means for reducing the partial pressure of oxygen and nitrogen in the vessel comprises a vacuum pump.

4. Apparatus according to Claim 1, 2 or 3, wherein the means for reducing the partial pressure of oxygen and nitrogen comprises pump means for flooding the vessel with a relatively inert gas.

5. Apparatus according to Claim 4, wherein the relatively inert gas is carbon dioxide.

6. Apparatus according to any one of the preceding Claims, wherein the means for applying mercerisation liquid to the fibre comprises means for pumping mercerisation liquid into the vessel.

7. Apparatus according to Claim 6, wherein the means for applying mercerisation liquid to the fibre comprises means for pumping mercerisation liquid, at a pressure greater than atmospheric pressure, into the vessel.

8. Apparatus according to anyone of the preceding claims, which apparatus further comprises means for applying washing liquid to the fibre.

9. A method for mercerisation of fibre, which method comprises the steps of tensioning the fibre to be mercerised to prevent contraction thereof, reducing the partial pressure of oxygen and nitrogen surrounding the fibre and applying mercerisation liquid to the fibre.

10. A method according to Claim 9, wherein the fibre is tensioned by compression of the fibre to a density of from 500 to 700g per litre.

11. A method according to Claim 9 or 10 wherein the partial pressure of oxygen and nitrogen is reduced so that the partial pressure of oxygen and nitrogen surrounding the fibres is from 5 to 8mm Hg.

12. A method according to Claim 9, 10 or 11, wherein the partial pressure of oxygen and nitrogen is reduced by reducing the atmospheric pressure surrounding the fibre.

13. A method according to any one of Claim 9 to 12, wherein the partial pressure of oxygen and nitrogen is reduced by flooding the space surrounding the fibre with a relatively inert gas.

14. A method according to any one of Claims 9 to 13, wherein the mercerisation liquid is applied to the fibre at a pressure greater than atmospheric pressure.

15. A method according to Claim 14, wherein the mercerisation liquid is applied to the fibre at a pressure of at least 3 bars.

16. A method according to Claim 15, wherein the mercerisation liquid is applied to the fibre at a pressure of at least 10 bars.

17. A method according to any one of Claims 9 to 16, wherein the mercerisation liquid is at a temperature of from 14° to 30° C.

18. A method according to any one of Claim 9 to 18, wherein the mercerisation liquid comprises caustic soda or liquid ammonia.

19. A method according to Claim 18 wherein the mercerisation liquid comprises caustic soda at a concentration of between 28° and 30° Be.

20. A method according to any one of Claims 9 to 17, which further comprises the step of applying washing liquid to the fibre.

21. A method according to Claim 20, wherein the washing liquid comprises water.

22. A method according to Claim 21 wherein the water is at a temperature of from 60° to 80° C.

23. A method according to any one of Claims 9 to 22 wherein the fibre is raw cotton fibre.

24. A fibre mercerised in apparatus according to any one of Claims 1 to 8 and/or in accordance with a method according to any one of Claims 9 to 23.

25. Apparatus for mercerisation of fibre substantially as hereinbefore described with reference to, and as shown in, the accompanying drawing.

26. A method for mercerisation of fibre substantially as hereinbefore described.

27. Any novel feature or combination of features described herein.

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